GROUND CONTROL PLAN GUIDELINES

The ground control plan for the safe control of all highwalls, pits, and spoil banks at the mine should contain information for each type of production equipment used at the mine. This information should show the methods of mining employed to ensure highwall and spoil bank stability so as to provide for safe working conditions. The methods used should be consistent with prudent engineering design in that actual mining processes will provide a safe margin of safety for workers exposed to highwall and spoil bank hazards. These hazards include the ground failing to support persons or equipment in a work area or material falling or sliding into a work area from above.

1. GROUND SLOPE

If the original ground slope exceeds 27 degrees, it becomes more difficult to operate a dozer on the ground to effectively strip loose, hazardous material a safe distance from the top of proposed highwalls when benching for first cuts and to slope any loose, unconsolidated material to the angle of repose. In these instances it is usually practical to establish a drop bench for first cuts to protect workers. Work to be performed during later development of the pit could be curtailed if the width of these benches is not capable of keeping any loose, hazardous material from falling into the work areas to be developed below.

If drop benches are to be used, the plan will have to reflect this (show in the engineered drawing).

2. HIGHWALLS

The height of a highwall should not exceed the reach of the type of equipment available at the mine to clean (scale) the highwall unless special precautions are taken. These precautions could include blasting practices that shoot the face of the highwall clean, using equipment that is capable of working out a safe distance from the base of the highwall while removing material to the toe (such as a shovel), using equipment to clean the wall from the top edge, breaking the wall down into benches that are spaced so as to allow for cleaning of the wall immediately above the work area, or providing a buffer (such as a berm of material) at the base of the highwall that keeps workers out a safe distance from the wall.

The angle of a highwall (slope) is usually determined by the type of blasting used to develop the wall. When drilling vertically, the wall typically shoots out between 5 and 10 degrees unless presplit. Angle drilling at 10 to 20 degrees is being done in some instances where cast blasting occurs. The angle at which the highwall is developed should be included in the consideration of

pit widths. If an unsafe condition should exist or develop after a wall is established, the area to be barricaded will be determined by the extent of the unsafe area in the wall and the angle of the wall. Typically, material falling out of a vertical wall will land on the pit floor within the drop zone (see **width of benches** below) near the toe of the wall, whereas material falling out of an angled wall will kick out from the wall and would require a barricade to be established a greater distance from the base of the wall.

3. BENCHES

Bench spacings

Benches perform two important functions. **First,** they provide stability to a highwall by increasing the safety factor of the highwall. Where a highwall contains numerous discontinuities (joint sets, bedding planes, etc.), providing benches at select spacings can increase the stability of the wall. **Second**, where sloughing rock and dirt are a problem, benches can be used to keep these materials from falling into the pit. One of the factors used to determine bench spacings would be their ability to perform the above functions.

Where bench spacings have been decreased to a minimum at surface mines and sloughing material is still not contained (smaller size material), it would be necessary to determine if a hazard is created by the sloughing material. It is likely that the bench spacing is such that the drop zone is minimal (the angle of the wall will affect the drop zone) and the material is simply falling at the base of the wall. This material may not be a hazard because it does not fall into a travel or work area. Assignment of work duties near the wall will be considered in determining if a hazard is created.

Another factor used to determine bench spacings would be the ability to maintain the exposed face of the highwall. If access is provided to both the top and base of a wall to make it possible for equipment such as end loaders and excavators to clean the wall, bench spacings up to 50 feet are practical. This is important to consider for the development of highwalls that will be exposed indefinitely, such as deep mine face-ups.

Highwalls developed for surface mining operations are normally not exposed for long periods of time, and the equipment used allows workers to minimize their exposure to these types of walls. This allows for extended bench spacings. Blasting techniques are selected to shoot the wall clean initially. Excavators are used to clean the lip of the wall and any developed bench before the shot is brought down. Dozers then clean the wall as the shot is brought down. The effectiveness of these cleaning operations, the shortened exposure of the wall to weathering, and the stability of the wall determine the extent of the bench spacings used. As long as the strata in the wall remains stable and workers in the pit are not subjected to material sloughing out of the wall, these methods are acceptable.

If the configuration of the highwall or techniques being used do not keep material from falling into the pit where workers are exposed, changes to the ground control methods are

necessary. Providing a bench or additional benches in the wall, widening bench widths, modifying blasting techniques, changing the orientation of mining, and more effective cleaning methods would be some of the changes to consider.

Developing benches at equal spacings in a wall and maintaining bench widths to equal those bench spacings provide for the best protection against shear plane failure. It may not be practical to break the wall down in this manner. Increased bench spacings may be necessary. Establishing a bench at 50 feet above the pit floor and having the next spacing occur at 70 or more feet increases the possibility that shear plane failure in the upper section of the wall would result in rock vaulting the bench at the 50-foot elevation in the wall and landing on the pit floor. For this reason it is important to maintain wider benches (sometimes exceeding the drop zone for the immediate wall above the bench) in order to contain material that may fall out of the wall above the bench.

When highwalls are not presplit, they usually shoot out at an angle (5-10 degrees). Because of this, bench widths will need to be wider than the drop zone width for the particular height of the wall in question. Bench widths less than 30 feet should not be used.

Whenever bedding planes exist running along in the wall parallel with the pit floor, consideration should be given to the possibility that the plane strikes at an upward angle back into the wall. This condition causes shear plane failure. Joint sets (mud seams) that intersect back in a wall in such a way that the intersection strikes at an upward angle are the cause of wedge failures. The direction that these joint sets run back into a wall can usually be determined. The strike direction of the intersection of these joint sets usually cannot be determined. When these discontinuities are exposed to changes in weather (freeze-thaw) and/or vibration (the detonation of a shot), failure of the material can occur with very little warning.

Protection against these hazards can be achieved by the strategic placement of benches in the wall at the elevation where these discontinuities are exposed in the face of the wall. This increases the safety factor of the strata where they exist. When a shot that was drilled deep is brought down, these conditions may show up high on the wall. The opportunity to provide a bench at the elevation of the discontinuities is no longer available. Either extending the width of the next bench to be established below these discontinuities, or limiting exposure to these hazards at the pit level by barricading (or a buffer), should be considered.

Joint sets that intersect back in the wall with the intersection extending vertical form what is termed “chimneys.” If the toe supporting this strata is solid and failure occurs, the “chimney” will usually tip out of the wall. If the toe is weak, a “chimney” can slide out into the pit bringing the material in the toe with it. These conditions should be corrected as they are exposed bringing the shot down. At no time should any person work below the top of a “chimney” in an attempt to dislodge it from the wall.

Where discontinuities present shear plane, wedge, or “chimney” failure concerns, changing the orientation of lifts (panels) can be a solution. Drilling on an angle or obtaining some angle with

production shots that are not presplit can be a solution to the "chimney" problem if a solid toe is supporting the "chimney." The weight of the rock causes it to lie back into the wall.

The **width of benches** should be determined by two factors:

First, the bench should be wide enough to contain any material that sloughs out of the wall from above the bench. It should be at least as wide as the drop zone width if the wall above is presplit or wider to contain material kicked out from the angle of any wall drilled on angle or developed without presplitting. It is recommended that benches be at least 30 feet wide. The drop zone for falling material is the area at the base of the highwall (on the bench or pit floor) within which most of the material falling out of the wall lands. The distance that this area extends out from the base of the wall is usually determined by measuring out from the base of the highwall a distance of approximately 25 percent of the highwall height. The drop zone for a 100-foot highwall would be approximately 25 feet. The width of the bench should accommodate this distance.

Second, the extended exposure of the wall can cause sloughing material to accumulate on the bench and may require cleaning to maintain the bench's effectiveness. If cleaning benches will be a function of the ground control plan, the bench width will have to be able to accommodate the width of any equipment used on the bench and safe access to the bench will have to be provided. Equipment with a track width of 12 feet should not be used on a bench less than 30 feet wide. This is determined by doubling the track width and allowing a margin for irregularity of widths caused by blasting. The effects of weather increases the potential for bench failure or changes in the wall located above and below the bench. An evaluation would be necessary to determine the stability of any bench and the wall above the bench before putting any type of equipment on the bench.

When developing a bench, its width is determined by the location of the drilled blast holes and the type of blasting to be done. Back break from the detonation of the blast can extend back into the bench as much as 10 feet. Presplitting can reduce back break if the holes are spaced close enough and plugged as near the top of the hole as possible to reduce the amount of stemming in the hole. Back break weakens the cap rock at the bench level. Explosive suppliers may offer other techniques that could be used to handle back-break problems.

When a drill sets up to drill a 30-foot bench, the holes will need to be drilled at least 40 feet from the base of the wall unless drilling presplit holes. As the shot is taken down, the back-break material will pull, leaving an approximate 30-foot bench. If holes are drilled 30 feet from the base of the wall, the result will likely be an approximate 20-foot bench, which does not give enough width to use equipment on the bench later to clean the bench. It is likely that some sloughing material will also vault the bench. **If this occurs, the ground control plan must be revised to provide for wider benches or other effective changes.**

Because of hidden conditions and extended exposure of some highwalls, it would be prudent to allow for bench widths that allow for continued maintenance of the bench if ground failure occurred at the bench level. This would require more pit width and is not always an option. The use of 40-foot bench widths is not uncommon where pit widths allow. Consideration should be

given to this when determining widths of benches that will be expected to function over a long period of time to ensure that mining operations are not curtailed at some later time because of highwall conditions.

4. SPOIL BANKS

Box cut spoil that is deposited by dozers pushing the material into place will be compacted more than cast material or dragline spoil. This is not the case for material pushed over a highwall by a dozer because the material actually falls into place. Industry experience has shown that if this compaction exists and the spoil material has a block consistency (the spoil contains large to medium size rock mixed with smaller material and dirt), it is possible to deposit this spoil at slightly steeper angles than the natural angle of repose if equipment or other weight load is not positioned or operated on the top of such piles. Success has been obtained using box cut spoil angles of up to 50 degrees where the above conditions existed. Other spoil pile configurations could be used if an acceptable safety factor is maintained.

Dragline spoil piles and end dump spoil piles should not have bank slopes that exceed the natural angle of repose of the spoil existing in the pile. This angle of repose should be determined for the spoil being handled at a specific mine because spoil consistency can change from one site to another. If this angle varies for different work sites at a mine, the ground control plan will have to identify spoil angles specific to the work sites.

The height of deposited spoil becomes important when spoil pile configurations incorporate different angles on a single face. This type of configuration is only acceptable for box cut spoil piles (piles that are compacted by dozers and not dumped in place). Establishing an angle steeper than 50 degrees at the base of these piles can be acceptable if the height of the steepened slope does not exceed the reach of the equipment available to clean the bank, the remainder of the slope above the steepened portion is cut back to the lesser angle, and an acceptable margin of safety is maintained. **If this method is used, the plan will have to show what the safety factor of the spoil pile is calculated to be.**

Any movement or bulging of the pile would indicate that the margin of safety is not acceptable and the slope would have to be cut down to a lesser angle.

5. PIT WIDTHS

To determine pit widths, consideration should be given to the type of equipment and the method of mining that will exist in the pit. Standards require that persons not be allowed to work near or under dangerous highwalls or banks and that unsafe ground conditions be corrected promptly, or the area posted. If pit widths are too narrow to allow for the barricading of unsafe ground conditions that may occur or for the safe staging of trucks while being loaded or the room for a roadway located away from the highwall, then mining operations may be curtailed. If large rocks are dug out of the shot bank that require secondary blasting, is there enough room to position them for drilling and still operate in the pit?

6. WORKING NEAR HIGHWALLS

The plan should take into consideration the location of persons in relation to spoil banks and highwalls when they perform their duties of drilling, blasting, working a shot, cleaning wall, chopping coal, and loading out coal.

The plan should not allow persons to work directly against a highwall. When working near highwalls the following safety precautions must be followed.

h. A bench is located in the highwall directly above the work area. The bench should be spaced so as to make it possible to clean the face of the immediate wall (the section of wall from the pit floor up to the first bench) with equipment available at the mine (see Item 3-Benches)

i. The worker is not positioned between the highwall and any part of any equipment that would hinder their escape from falls or slides

j. Safe access to the top of the highwall is provided to allow for examinations of ground conditions

k. The top of the highwall is cleaned of loose, hazardous material. This should be done before the shot material exposing the highwall is brought down. This work should be done with a machine such as an excavator that can reach the edge of the wall from safe staging and use the outward force of the bucket to remove loose material from the top edge of the wall.

l. A buffer is provided that locates the workers out a safe distance from the toe of the wall

7. END DUMP VALLEY FILLS

These fills are spoil piles that are unique in that they are established on inclined, original ground that typically has been altered by clearing operations that result in variable coefficients of friction between the material being placed and the original ground. This can result in slips on the face of the fill that do not usually occur in typical spoil piles. Because of the different friction coefficients existing in the pile, movement on the face of the pile does not always show up at the top of the fill as tension cracks. Until the material being placed keys into the valley floor or the opposing slope of the valley, the fill is unstable and movement on the face of the pile is normal.

Ground control plans should establish what the angle of repose of the outer slope of the end dump valley fills is for a specific mine or area of the mine. The method of mining used at these dump areas would include dumping a safe distance (not less than one truck length) back from the outer edge at the top of these fills where the slope of the outer bank becomes steepened beyond the established angle of repose and pushing the material to the edge of the fill. Double load the blade to push the material over the top edge of the fill. A track-mounted dozer should be used because it distributes the weight of the machine over a greater area than a rubber-tired dozer.

The method of mining used at end dump valley fills should require dumping back from tension cracks that exist in the top of the fill, leaving enough room for the dozer to cut a horizontal lift off the top of the fill beginning a safe distance back from the crack. Push the material over the outer slope to increase the safety factor for the slope. Then another lift consisting of the dumped material can be placed where the material was removed. This procedure will be less likely to top-load the edge of the fill and cause the edge to fail. After that material is placed, dumping near the edge could continue as long as tension cracks do not exist.

The method of mining used at end dump valley fills should include examinations made by a person experienced in ground control (this could be the dozer operator working the fill) often enough to determine that hazards do not exist at the dump site. The examiner would determine that the outer slopes of the fill are not steepened beyond the established angle of repose, that tension cracks do not exist, that adequate berms are maintained, that trucks or end loaders dumping over the edge do not roll against berms, and that water does not impound on the fill. When any of these hazards exist, supervision should be informed immediately and corrective action taken.

The use of earthen barricading is recommended (piled high enough to limit the access of persons or equipment). In addition to limiting access, the barricade (or buffer) will help control material sloughing into the pit. It is the most practical solution.

If draping is done it should be heavy wire mesh (chain link is sometimes used). This will allow for water to escape out of the wall and better observation of the wall for indications of failure. If gunite is used, weep holes need to be provided for the escape of water. The location of these weep holes does not always ensure that water escapes, and this can lead to deterioration of the draping. An additive should be added to the gunite to prevent acid damage.

Another justification for the use of spraying (normally to a depth of 1-2 inches) gunite draping is to keep surface weathering from occurring. A problem with the use of gunite is that water can accumulate in the strata of the wall at a later time and cause the draping to deteriorate.

Substantially constructed canopies of steel, reinforced concrete, or the equivalent have to be provided at all intended drift and slope openings prior to those openings being used by workers to enter or exit the mine. A 10-foot cut may be taken with a remote-controlled continuous mining machine for the purpose of installing the canopies under the edge of the highwall. The canopy must be installed and secured against movement prior to installing roof supports. The canopy has to extend from the highwall for a distance which will provide for adequate protection from falling highwall material. It is recommended that the canopy extend at least 30 feet from

Other Information Where Appropriate

SURFACE BLASTING

Describe the blasting procedures and type of explosives used:

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_____

_____

_____

_____

Describe the drilling equipment:

_____

_____

_____

_____

Drill Hole diameter: _____ Hole Depth: _____

Hole Spacing: _____ ft. by _____ ft.

Angle of hole: _____ degrees

Is pre-splitting to be done? [ ] Yes [ ] No